MDE Product Development Team
January 2013 Monthly Report
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Executive Summary

Task 1: Improve turbulence guidance from NWP forecasts

- RAP version 2 running at GSD, continuing to yield improved upper-air wind/temp/RH forecasts over RAP-NCEP. The same is true for surface moisture and precipitation forecasts.
- Further changes in testing in development (not primary) ESRL RAP including data assimilation and modeling improvements. All of these will be included in final Rapid Refresh v2 (RAPv2) with implementation at NCEP, now proposed for early 2014 after NCEP implementation moratorium is lifted.
- There are 3 parallel RAP cycles (dev1, dev2, dev3) now running on the Zeus NOAA research supercomputer located in Fairmont, WV. (dev1 – updated land-surface model and surface roughness, dev2 – WRFv3.4.1 + MYNN PBL, dev3 – hybrid/ensemble data assimilation).
- ESRL testing hybrid/ensemble data assimilation in real-time parallel RAP of 80-member GFS global ensemble data to help specify background error covariance information, to be included in RAPv2
- Positive results (reduction in upper-level high relative humidity bias without degradation to low-level ceiling verification scores) from refined cloud analysis procedure, through selective use Effective Cloud Amount parameter provided by the CLAVR-x (Clouds from AVHRR [Advanced Very High Resolution Radiometer] Extended) satellite data.
- Multiple presentations on latest RAP data assimilation work at AMS Integrated Observing and Assimilation Systems (IOAS) Conference in January
- NCEP making progress on NAM and NAM-nest
- Operational RAP including RAP GSI component successfully ported to new WCOSS machine
- Continued rapid progress on testing and evaluation of RAP data assimilation (and model) changes within the RAP real-time parallel and retrospective cycles including"
  -- use of global ensemble information within GSI-based hybrid assimilation procedure for RAP
  -- improvements to RAP radar-based hydrometeor building and clearing
  -- improved cloud assimilation from selective use of Effective Cloud Amount parameter provided by the CLAVR-x (Clouds from AVHRR Extended) satellite data.
- Merge of RAP GSI with NCEP SVN trunk, soil adjustment code submitted back to community trunk.
- Discussions with EMC, NSSL, and CAPS personnel at Norman Warn-on-Forecast (WoF) meeting on assimilation strategies and use of RAP/HRRR and their ensembles for WoF.

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Began transfer of real-time HRRR fields from JET to NCEP Central Operation (NCO) for distribution
- Continued real-time parallel testing of 3-km, 15-min radar reflectivity assimilation during a 1-h pre-forecast cycle for the HRRR.
- Parallel testing of 3-km radial velocity assimilation for the HRRR
- Real-time experimental HRRR-based RTMA 2D surface analysis and RUA cloud analysis running on Zeus with graphics (including "analysis – background" plots) available on web and quantitative "fit to observations" verification.
- ESRL is also running on Zeus a parallel 3-km HRRR as well as an experimental 2D RTMA surface analysis application using HRRR forecast as background.

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- 9-level RUC land-surface model is producing much improved near-surface wind forecasts and also improved 2m temperature forecasts

- Integration of bug correction into RAP/ WRF regarding lack of radiation effects from snow mixing ratio in atmosphere, which has been contributing to a daytime warm bias in the RAP and HRRR at the surface.
- Improved lower-troposphere and near-surface forecasts of especially of wind are now being produced from the GSD/Olson version of MYNN boundary-layer scheme.
- NCAR/RAL making excellent progress on aerosol-aware microphysics

Task 4: Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

- Continued progress and encouraging results from retrospective HRRR experiments using a 3-km, 15-min cycling, one-hour pre-forecast radar assimilation period, is now planned to be applied in the real-time HRRR for 2013.
- Initial tests of a fully cycled 3-km assimilation using GSI for the HRRR and 3D 3-km application for the Rapidly Updated Analysis (RUA).
- Multiple presentations on latest HRRR results at AMS Aviation, Range, and Aerospace Meteorology (ARAM) Conference in January.

Task 1: Improve turbulence guidance from NWP forecasts

Improving turbulence forecast quality would involve efforts to improve initial conditions for the RAP and NAM (and HRRR and NAM nests) and to improve the models (WRF-Advanced Research WRF (ARW)-RAP and NOAA Environmental Modeling System (NEMS)- Nonhydrostatic Multi-scale Model – B (NMMB)).

Tasks will include:

- Continuing evaluation of RAPv2 toward summer 2013 implementation at NCEP, incorporating changes developed in 2012.
- Collaborating on developing & testing best approaches for use of hybrid/EnKF/3DVAR within common GSI coding structure.
- Collaborating on developing and testing physics schemes between WRF and NEMS' physics layer.
- Negotiating Data Mining List priorities with NCEP Central Operations and external points of contact associated with the most desirable new sources of observations. (NCEP and ESRL)
- Continuing final testing of RAPv3, including initialization of the HRRR.

ESRL

Regarding the NCEP RAP

The operational RAP at NCEP continues to run without any technical problems (including with the post-processing) during the quarter. The RAP continues to show improved reliability over the previous RUC at NCEP.

Geoff Manikin reports that the NCEP RAP is now converted to run on the new WCOSS computer. Geoff cites work by Ming Hu of GSD as critical to this process. Next will come testing of a parallel cycle on the WCOSS machine. Once this is successful. Geoff Manikin is prepared to begin accepting updated RAPv2 code from GSD for testing on the WCOSS computer. We now anticipate that this may be possible by late spring or early summer. However, based on discussions with EMC, operational implementation of RAPv2 still appears unlikely before early 2014, owing to a growing backlog of implementations to be made after the current moratorium on implementations is lifted.

Regarding the ESRL RAP

The principal thrust of RAP work at ESRL/GSD during January continued toward further improvements to the RAP in preparation for freezing the HRRR for the summer 2013 convection season and the transfer of RAPv2 code to NCEP.

In late December with the advent of more typical winter weather and significant snow in various parts of the CONUS, some defects in performance of the RAPv2 were noted and January saw a concentrated effort to diagnose and fix these problems:

- Ceiling height at initial time. Using the GSD verification system, the probability of detection – yes (PODy) of MVFR and IFR ceiling heights was found to be far inferior to that of the NCEP RAP for the same thresholds. That this was clearly an analysis problem was apparent from the rapid decrease in difference between the NCEP RAP and the GSD cycles during the forecast.

- Deficient snow cover. This was noted in routine monitoring of RAP snow cover and comparing with the NOHRSC (NOAA Operational Hydrologic Remote Sensing Center) snow cover and snow-water equivalent products, as well as visible satellite imagery.

- Model crashes caused by too cold soil temperature under snow cover.

The first of these were traced in large part to a new procedure for specifying partial cloud cover in the GSD cloud analysis. However, this was not the whole story, as a new review of the GSI cloud analysis code revealed that changes to the treatment of snow hydrometeors intended to avoid the summertime moist bias exhibited by the operational RAPv1 had not been coded as intended.

We recognized that this erroneous removal of snow hydrometeors aloft when lowest level temperature was < 5C was probably also responsible for the deficient snow cover, since cycled snow accumulation depends on the 0-1h forecast of model precipitation. The code was fixed in late January and both snow cover and ceiling verification appear to be much improved, although monitoring continues.

As for the model crashes, this was attributed to the soil temperature and moisture adjustment introduced into RAPv2 late in 2011. This had been successfully introduced into the operational RUC some years ago [2007?], and functioned without problem in GSD RAP cycles during winter 2011-12. However, persistent extremely cold daytime (and nighttime) valley temperatures in many areas of the West occurred from mid-December 2012 through mid-January 2013. By and large this cold was not adequately forecast by RAP (at least partially as result of deficient snow depth), so that daytime 1-h forecast background temperatures were persistently warmer than the METAR observations, resulting in accumulated downward adjustment of soil temperature in the first two levels of soil (largest at the first level). Eventually top-level soil temperature got so cold at one point in southwest Wyoming that it was persistently below the range of soil temperatures allowed by the RUC LSM. Turning off the soil temperature and moisture adjustment when there is snow cover removed the problem. Currently, a modified adjustment procedure when there is snow cover is being evaluated.

During January we continued to dedicate one of the Zeus cycles to testing pertaining to GSI, and the other two for various model enhancements. We also continue to use the late May early June 2011 retro period for assessment of warm-season performance of candidate changes to RAPv2 in preparation for the March code freeze. These candidate changes include the following, with reference to places where more detailed discussion may be found:

- Use new hybrid variational / Ensemble Kalman Filter option in GSI in place of the current 3dVAR for analysis of the non-hydrometeor meteorological state variables (See Task 5). Earlier testing in December was very favorable.
- GSI cloud-analysis enhancements including the corrected treatment of hydrometeors discussed above and modifications to better account for partial cloud analysis, including use of the NESDIS-produced Effective Cloud Amount field and to distinguish between BKN and OVC sky condition in METAR surface observations. (Task 5)
- Upgrade to the most recently released version of the WRF code (v3.4.1 released August 2012) from v3.3.1, released August 2011), including RAP enhancements. This package contains an upgrade to the NCAR Thompson microphysics currently used in RAP and proper microphysics coupling with the Goddard short-wave radiation scheme used in RAP.
- Major physics upgrades not available in the most current WRF official release (v3.4.1) [additional description under Task 3]
    - RUC land-surface model (LSM) with increase in vertical resolution from 6 to 9 levels and enhancement to surface roughness fields (including seasonal changes in roughness in agricultural areas). (FY12Q1 report and Task 3 in this report.
    - The December 2012 version of the new Grell-Freitas deep and shallow convection scheme, including accounting for attenuation of short-wave radiation by convective clouds (task 5.8)
    - The MYNN planetary boundary layer (PBL) and surface layer scheme (with current GSD enhancements) in place of the current MYJ scheme.

Testing to date has already shown the advantages of many of these changes, but decision on a final configuration waits further real-time and retrospective testing, including evaluation of the impact of these RAP changes on HRRR performance.

We have also been developing or testing several possible HRRR enhancements for both assimilation and model. See Task 2 for further discussion.

GSI efforts toward RAPv2 from ESRL

1. Work on use of data from the 80 GFS global ensemble data assimilation ensemble members to improve the RAP mesoscale assimilation and forecast continues with inclusion in the 2013 warm season code freeze and the RAPv2 code transfer to NCEP almost certain. Following an initial ~ 1 month real-time test period in Nov./Dec. 2012, this ensemble assimilation system, which showed very positive results, this configuration is being run in the GSD RAP-dev3 real-time parallel cycle in Zeus and being investigated more fully in a controlled week long retrospective evaluation (for a test period from late May / early June 2012), using GFS ensemble files provided by Darryl Kleist from EMC.

2. Improvements to the use cloud analysis through selective use of Effective Cloud Amount (ECA) parameter provided by the CLAVR-x (Clouds from AVHRR [Advanced Very High Resolution Radiometer] Extended) satellite data. By allowing a more selective building in mid- and upper-level regions where the ECA) parameter indicates only limited partial cloudiness, the new procedure reduces the high bias in mid- and upper-level high relative humidity without degrading the low-level ceiling verification scores.

Ming Hu successfully merged the GSD RAP GSI with the NCEP SVN trunk, enabling GSD access to the latest improvements form the GSI community. Ming also submitted the GSD group GSI code changes to apply the surface innovation-based soil temperature and moisture adjustment.

Haidao Lin continued his work on obtaining improved results for AIRS satellite radiance assimilation. Finally, GSD assimilation scientists participated in discussions with EMC, NSSL, and CAPS personnel in Norman, OK at a Warn-on-Forecast (WoF) workshop. Ideas and strategies for data assimilation to address short-range high impact weather forecast needs were discussed, including plans for use of the RAP/HRRR and their ensembles.

Other activities, some noted more fully under other tasks, also were undertaken:

- The NCAR WRF developers made a first beta release of WRFv3.5 available for testing by friendly developers in late January. This includes a number of contributions by GSD developers that are being evaluated for inclusion in the March 2013 RAP code release discussed earlier: the latest version of the RUC LSM (Smirnova), the Grell-Freitas deep and shallow convection, the MYNN PBL and surface-layer schemes updated through late December (Olson) and the current version of the RAP digital filter initialization (Peckham and Smirnova). Tanya Smirnova has made some preliminary non-cycled runs with this release.
- Continued evaluation of the Earth Networks, Inc. lightning data for use as a possible alternative to the Vaisala GLD360 lightning product.
- Retrospective testing of satellite radiance bias corrections and choice of background error (Task 5).
- Retrospective testing for both RAP and HRRR of the impacts of proprietary in situ tower wind data and other special data continues under funding from the DOE Wind Forecast Improvement Project.
- Several RAP and HRRR related papers were given at the Austin TX national meeting of the American Meteorological Society, 7-10 January 2013. [Jmb can canvass folks for these if appropriate.]

NCEP

Efforts to port all RAP code and scripts over to the new WCOSS computer platform are continuing. A successful end-to-end model run was achieved during the middle of January. For the rest of January the team worked on validating the products - verifying that the output from the runs on WCOSS closely matched that from the accompanying operational runs on the CCS. The codes and scripts will be turned over to NCO during the first week of February. Now that NCEP is in a moratorium on implementations, the upgrade to RAPv2 is not likely to be scheduled until FY 2014. (Geoff Manikin)

The transitioned codes to generate the Time–Lagged North American Rapid Refresh Ensemble (NARRE-TL, see **http://www.emc.ncep.noaa.gov/mmb/SREF_avia/FCST/NARRE/web_site/html/icing.html**) were turned over to NCO in early January. NCO began running test cases and those results were compared to similar runs on the CCS to validate that the WCOSS output matches the operational version. The initial validation test was successfully completed. (BinBin Zhou and Jun Du)

The transition to WCOSS of the observation processing codes for the Rapid Refresh continues. As of the end of January, the satellite ingest codes are essentially complete, the dump processing codes are 80% complete and work has begun on the critical 'prep' codes. (Dennis Keyser)

Near-real-time parallels of the NAM and its NAM Data Assimilation System (NDAS) have been maintained on both CCS and Zeus computer systems. The NDAS system in all parallels is using a hybrid variational-ensemble analysis with ensemble perturbations generated from the global EnKF system. In this technique members from the ensemble used in the global EnKF system are used to improve the background error variance, covariance and cross-covariance. The flow-dependence this brings in cannot be accomplished with the static background errors currently used in NAM & RAP. The use of this technique has produced significant improvement in the synoptic scales of the subsequent NAM forecasts and is being / will be used in RAPv2.1. The additional changes in GSI and NDAS and new data include: use GOES-15 radiances, use of variational QC scheme inside GSI, use of Meteosat 10 (in place of 9), use of satellite wind subtypes with different data thinning, radiosonde level enhancement in GSI (it is dependent on model vertical spacing), use mesonet wind observation reject list from RTMA, use new VAD wind profiles from Doppler radars, and use GPS bending angle observations (replaces use of refractivity with bending angle from satellites GRACE A, COSMIC 1-6, METOP A, adds use of bending angle obs from TSX, SAC-C, C/NOFS and includes setting cut off height to 30 km or roughly 12mb). (Eric Rogers, Shun Liu, Wan-Shu Wu)

A near-real-time parallel RTMA has been maintained on the CCS computer system for CONUS (2.5km) and Alaska (3km). Following several weeks of transition work and the successful completion of testing of the RTMA system on the WCOSS computer, a formal request to transfer the WCOSS version of the RTMA was submitted to and accepted by NCO. Work was initiated to add the analysis of 10-m wind speed and a GLERL-type analysis for lake winds to the GSI. Work to update the metadata list for surface observations was also initiated. Among other applications, the metadata list is to be used for the GLERL-type wind analysis in the GSI. (Manuel Pondeca, Steve Levine)

The level2 radar data processing codes were transitioned from CCS to WCOSS. The LEVEL2, MOSAIC and REF2GRB packages were recompiled on WCOSS. Scripts and codes were modified so these packages ran on WCOSS and the output from WCOSS runs were compared with those from CCS. These three packages will be turned over to NCO in early February for implementation on WCOSS. (Shun Liu)

The off-line parallel test for variational quality control, using subtypes for satellite winds and change of gross check bounds was completed. Variational quality control was an advanced buddy check method that was needed for the regional NDAS since it has no OIQC. However, the method was not effective in removing a group of bad ACARS data all in the same area. The subtype of satellite winds allowed separate treatment for data from various satellites in GSI, i.e., different quality control, data thinning, and observational errors could be used for data from each satellite. The short term forecast impact from these changes was small but positive. The changes were incorporated into the official NDAS parallels so that they would be included in the future operational implementation. Work was also done to check and replace satellite winds from Meteosat_9 with Meteosat_10. Since these data were not used in the operational NDAS, no emergency RFC was needed but the version of GSI used in the parallels was changed. Data thinning for the satellite winds from Meteosat_10 was also turned on. (Wan-Shu Wu)

CAPS

During January, CAPS submitted a co-authored paper (Zhu et al. 2013) documenting the EnKF performance for a 10-day long testing period. The abstract is reproduced below:

"A regional ensemble Kalman filter (EnKF) system based on the NCEP operational Grid-point Statistical Interpolation (GSI) system is established for the target Rapid Refresh (RAP) application. The system borrows data processing and observation operators from the GSI, and pre-calculates observation priors using the GSI. The ensemble square-root Kalman filter (EnSRF) algorithm is used which updates both the state vector and observation priors.

All conventional observations that go into the operational RAP GSI are used. To keep computational cost more manageable, the EnKF is run at 1/3 of the operational RAP resolution or about 40 km grid spacing, and its performance is compared to the GSI using the same data sets and resolution. Short-range (up to 18 hours, the

RAP forecast length) forecasts are verified against soundings, surface observations, and precipitation data. Experiments are run with 3 hourly assimilation cycles over a 9 day period from spring 2010 having active convection. Extensive tuning including the use of height-dependent covariance localization scales and adaptive covariance inflation improved the EnKF performance. When the EnKF employs multiple physics parameterization schemes, forecast errors are further reduced, especially in relative humidity and temperature at the upper levels and in surface variables. The best EnKF configuration produces lower forecast errors for the full forecast length for all variables at all levels. Gilbert skill scores of precipitation forecasts on the 13 km RAP grid initialized from the 3 hourly EnKF analyses are consistently better than those from GSI analyses. "

Due to drastic reduction of FY13 funding to CAPS, CAPS focused its effort on documenting the EnKF/hybrid results in a journal article during the period.

Reference cited:

Zhu, K., Y. Pan, M. Xue, X. Wang, J. S. Whitaker, S. G. Benjamin, S. S. Weygandt, and M. Hu, 2013: A regional GSI-based EnKF system for the Rapid Refresh configuration: Results with a single, reduced resolution. Mon. Wea. Rev., Submitted.

Additional information on RAP-related tasks

ESRL

After having no non-radar data available for the GSD RAP primary cycle since the RUC stopped running operationally at NCEP on 1 May, early PrepBUFR files (with incomplete radiosonde observations) were again made available to GSD on 27 November by NCEP Central Operations (NCO) for the 00z and 12z RAP runs at ESRL to initialize the HRRR. There was another subsequent outage from 22 Dec 2012 through 25 Jan 2013, when it was restored again. This is noted in a FAQ webpage for the HRRR at **http://ruc.noaa.gov/faq/HRRR.faq.html.**

GSD continues to make pgrb and bgrb files from the ESRL/GSD RAP-primary (RAPv2) real-time 1-h cycle available from its FTP site for users in NWS and other labs).

NCEP

NCEP maintained real-time availability of SAV and AHP guidance to all vendors from the operational hourly RAP on pressure surfaces via the NWS Family of Services (FOS) data feed and via the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (EMC&NCO)

NCEP maintained real-time availability of full resolution gridded data from the operational RAP runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/rap/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.rap_CY.00 through MT.rap_CY.23. This includes hourly BUFR soundings and output grids, which undergo no interpolation. Both sites now contain only grids in GRIB2 format **http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml.** Gridded RAP fields are now also available on **NOMADS** for the CONUS domain on 13 km grid #130 and the larger North American domain on 32 km grid #221. A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov/NCOMAGWEB/appcontroller.** (EMC&NCO)

Verification of RAP

ESRL's verification of the RAP is available from **http://ruc.noaa.gov/stats**. NCEP maintained its capability and provided access to routine verifications of the operational RAP analyses and forecasts. These include grid-to-station verifications versus rawinsonde, surface, aircraft, Profiler, and VAD data computed periodically at NCEP and accessible via NCEP's Mesoscale Modeling Branch website: **http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html** .

Deliverables	**Delivery Schedule**

Deliverables	Delivery Schedule
Task 1 – Improve turbulence guidance from NWP forecasts	
Finalize code for RAPv2 for implementation at NCEP • Good progress toward this deliverable.	Mar 2013
Complete the testing of the 40/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data • ESRL testing hybrid DA in RAP with full observational data, exceeding milestone, using GFS ensemble data.	Mar 2013
Report on early version of RAPv3 primary cycle at GSD with physics enhancements for initialization of the HRRR.	Dec 2013
Report on the optimal configurations for including satellite data in the 40/13 km dual-resolution hybrid system to ensure overall positive impacts of the data	Dec 2013
Finalize RAP version to initialize experimental HRRR for 2014 real-time use toward operational HRRR	Mar 2014
Deliver progress report on development of NARRE	Mar 2014
Deliver progress report on ensemble/hybrid data assimilation for use in NARRE	Mar 2014

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

GSD

In January 2013, work continued on single-case and multi-day retrospective testing of the HRRR in conjunction with RAP testing toward a final set of improvements for an anticipated mid-March code freeze for a warm season evaluation. Testing has focused on use of radar reflectivity and radial velocity at 3-km. Tests of a 3-km 15-min cycled 1-h radar-assimilation pre-forecast have yielding encouraging results, but the method still requires some adjustment to maximize the utility of both the radar and conventional observations. Additional retrospective testing of use of level-2 radial velocity data within a 3-km full-GSI analysis is ongoing.

Significant improvements were also made to the RAP radar-based hydrometeor clearing and building algorithm. Detailed analysis of initial grids revealed issues with the precipitation clearing and building that have been corrected, leading to a procedure that successfully: i) for cold-season conditions (Tsfc < 5C) specifies qs at all radar observed levels with Z > 0 dBZ and clears qs, qr, qg for all radar levels with Z < 0 dBZ and ii) for warm-season conditions (Tsfc > 5C) specifies qs at the single maximum radar observed level and clears qs, qr, qg for all radar levels with Z < 0 dBZ. Real-time results indicate the desires effect of better location of small-scale features such as lake effect snow bands and we anticipate avoidance of the high soil moisture bias problem that previously resulted from full-column precipitation building during the warm-season.

Work in two other important areas is ongoing. First, a key milestone was achieved on Feb. 14, when real-time transfer of HRRR grib2 output files from JET to NCEP Central Operations (NCO) commenced, which will enable NCO distribution of the research regular HRRR grids. Second GSD scientists and IT personnel continue to work with NCEP IT specialists to complete key file transfer links that would enable complete independence between the JET and ZEUS real-time experimental RAP/HRRR systems. This work involves obtaining independent feeds of key observations and parent model grids to the JET and ZEUS machines and obtaining independent transfer and dissemination of the output grids from the machines.

Work also continues in coordination with EMC and NSSL colleagues on further developing and evaluating HRRR-based Real-Time Mesoscale Analysis (RTMA) and Rapidly Updates Analysis (RUA) products.

Deliverables	**Delivery Schedule**

Task 2 – Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	
Report on initial tests of 3-km 15-min RTMA cloud / surface analysis for use in frontal diagnostics, CI assessment and other near-surface assessments • *Good progress toward 3km RTMA and RUA surface and cloud analyses*	Feb 2013
Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for 2013 real-time use • *Good progress toward significantly upgraded HRRR for 2013 real-time use.*	Mar 2013
Provide preliminary 15-min RTMA surface analyses as experimental improved basis for frontal diagnostics and other diagnostics from surface analyses	Apr 2013
Report on computing resource status on NCEP Central Computing System, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR	Jun 2013
Complete FY13 internal assessment with revised 3-km HRRR running every hour	Sept 2013
Provide revised 15-min RTMA surface analyses as primary basis for frontal diagnostics and other diagnostics from surface analyses for real-time use in 2014	Feb 2014
Finalize all changes to the HRRR for real-time use in 2014	Mar 2014

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

GSD

Summary: Extensive testing and evaluation continued in January directed toward a final decision on the physics configuration in the RAPv2 code to be frozen in March 2013. Most emphasis was given to the land-surface model (LSM), boundary layer and convection. This is detailed below.

As a result of the successful testing of major revisions to the RUC LSM coupled with enhancements to the land-surface fields used by the LSM (see MDEFY13Q1 report), we plan to soon introduce the new 9-level configuration into all the GSD RAP cycles, including the RAP-primary that drives the HRRR. The increased resolution improves 2-m temperature forecasts during the evening transition without leading to cold biases at other times of the day or in winter conditions of snow cover and reduced insolation. Further, the 10-m wind performance has been improved by the modifications to land use and land-surface properties discussed in the FY13Q1 report.

The concerted effort by Tanya Smirnova and Joe Olson in December 2012 to find and correct the cause of the excessive occurrence of nighttime fog over snow-covered areas has kept the MYNN PBL and surface layer as a strong candidate to replace the MYJ because of it's overall improved wind forecasts. However, further testing is needed before a decision is made. Further modifications to the surface layer pertaining to the roughness length for heat (essentially a complex tuning parameter affecting the surface heat flux) are under consideration and will soon be evaluated.

After extensive testing, we now consider the new Grell-Freitas convective scheme with the shallow convection and radiation feedback options turned on to give slightly better or at least comparable performance to the v3.2.1 version of the Grell G3 scheme currently in RAPv2 for predictions of wind, temperature, and relative humidity. Some further testing is needed to confirm that precipitation forecasts are satisfactory.

In a related effort, David Dowell and Curtis Alexander introduced code into the GSI cloud analysis to ensure that the conversion between reflectivity and mixing ratios of rain, snow and graupel are consistent with the v3.4.1 Thompson scheme.

GSD has had some discussions with the NCAR WRF developers concerning small-scale oscillations in low-level fields under conditions of steep terrain slope and strong surface wind when the 6^{th} order diffusion is turned on. However, a definitive solution awaits further effort.

Very good results from 9-layer RUC LSM and other enhancements to use of fixed surface fields – see subtask 1. These are now in parallel testing, and are likely to be made part of the RAPv2 suite of changes, as well as being incorporated into the HRRR.

NCAR/RAL

CURRENT EFFORTS: During the month of January, the Thompson et al (2008) microphysics scheme with explicit treatment of aerosols was tested. More information about results will be prepared once FAA funding arrives at NCAR-RAL, but all work was stopped part-way into the month due to funds not yet being transferred.

PLANNED EFFORTS: Initial code tests appear very successful so arrangements will be made to resume work once 2013 funds become available.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: FAA funding for 2013 has not yet arrived at NCAR-RAL; so all employees were informed to stop work on the project.

INTERFACE WITH OTHER ORGANIZATIONS:

NCAR/MMM

NCAR has conducted a WRF tutorial at its Foothills Lab January 28–February 5, 2013. There will be a WRF tutorial and a MET (Model Evaluation Tools) tutorial. Approximately 60 participants attended the tutorial. The tutorial is further described at: **http://www.mmm.ucar.edu/events/tutorial_131/index.php**.

PLANNED EFFORTS: NCAR will prepare another WRF tutorial in Boulder in July 2013.

UPDATES TO SCHEDULE: NONE

NCAR and the WRF Release Committee continued to prepare for the next major release, which will be WRF Version 3.5. The release is planned for Spring 2013, and details may be found at: **http://www.wrf-model.org/release.php**. Candidate features include software framework improvements, new physics options, new observation types for WRFDA, and WRF-Chem additions.

The freeze date for the code has passed, and the received contributions are now being tested. Bugfixes are being made as necessary. NCAR has issued the first friendly-user pre-release. After feedback from this, a second one will be made in mid-to-late February.

Jimy Dudhia of NCAR obtained updated code from Hugh Morrison (NCAR/MMM) for his microphysics scheme. The modifications improve cirrus cloud simulations, and are going into the V3.5 release.

Dudhia added lightning diagnostic code from John Wong (Univ. Colorado) to the WRF repository. The code estimates lightning flash rates, and it can now be run independently of WRF-Chem.

Dudhia began working on improving the timekeeping used in diagnostic computations in longer WRF simulations. It has been seen that problems can occur as the time variable (e.g., xtime) gets large.

NCAR personnel migrated WRF code testing to the new NCAR HPC "yellowstone", located at the NCAR-Wyoming Supercomputer Center. Dudhia worked on determining, which physics options, and combinations are failing the standard software tests (i.e. TEMF, NoahMP, SSiB SLM, 3-D Miami ocean model). These physics packages are foci to fix prior to the V3.5 release.

Dudhia hosted visitor, Songyou Hong (Yonsei Univ.) to collaborate on YSU PBL wind biases (with Pedro Jimenez, CIEMAT, Spain), shallow convection (Wei Wang, NCAR/MMM), and WSM5 microphysics in the TTL (tropical tropopause layer) with collaborator Stephanie Evan (NOAA).

Dudhia advised Greg Thompson (NCAR/RAL) on his effort to make radiation scheme codes in WRF consistent with particle sizes from different microphysics schemes. The work entails providing particle size information to the radiation packages.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP will continue through FY13Q2.

UPDATES TO SCHEDULE: NONE

Task 3 – Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	
Complete initial evaluation of aerosol-aware microphysics in RAP real-time cycling at GSD for its suitability as part of the RAPv3 prototype for 2014 NCEP implementation	Feb 2013
Final model physics code transfer complete to EMC for Rapid Refresh 2 upgrade change package to be implemented at NCEP in summer 2013	Mar 2013
Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v2 software to NCO	May 2013
Transfer upgraded coupled aerosol-microphysics scheme into a test version of HRRR	Dec 2013
Finalize microphysics changes and other physics changes to improve icing forecasts for ESRL version of RAP and HRRR for 2014 real-time use	Mar 2014

Task 4: Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

Task 4 – Conduct baseline testing of the early 2013 HRRR version

Current:
Execution and evaluation of candidate changes to the ESRL RAP and HRRR for 2013 are underway including 3-km radar reflectivity data assimilation within the HRRR for a one-hour spin-up period from 13-km RAP initial conditions. The reflectivity forecast evaluation of the HRRR one-hour spin-up radar data assimilation experiment is now complete for the May/June 2011 retrospective period and the results show improvement in the 0-4 hour lead time period with the most notable improvement of CSI in the first two forecast hours. We are anticipating improvement in very short-term forecasts (first few forecast hours) of air mass thunderstorms and other small-scale convective structures in the real-time HRRR model forecasts with 3-km radar data assimilation. Curtis Alexander installed this experimental configuration in a real-time parallel version of the HRRR in late January to begin a real-time parallel evaluation of this change.

Additional experimentation of GSI assimilation of radar radial winds at 3-km in the HRRR is also underway by Curtis Alexander, Eric James and Ming Hu with possible inclusion in the 2014 version of the HRRR.

RAP retrospective runs have been executed by Patrick Hofmann during the May/June 2011 retrospective period to test the new version of WRF (v3.4.1) including a new version of the Grell convective parameterization scheme along with updates to the data assimilation system, GSI, including building/clearing of precipitating hydrometeors from radar reflectivity observations. These retrospective runs have shown neutral to slight improvement in forecasts of upper-level temperatures, humidity and winds. More significant improvement in reflectivity forecasts was observed, particularly over the first few forecast hours, as measured by both CSI and BIAS.

Ming Hu configured real-time parallel RAP runs of updated GSI (Gridpoint Statistical Interpolation – the data assimilation engine for the RAP/HRRR) using an improved background error covariance specification using weather (flow) dependent GFS ensemble output that have also shown significant improvement in RAP forecasts with reduced RMS values for upper-level temperatures, humidity and winds and this indicates an improved forecast of the mesoscale environment from which the HRRR will be initialized.

Task 4 – Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use

***Current*:**
Ming Hu and David Dowell are developing an improved retrieval in GSI of rain and snow hydrometeors from radar reflectivity observations that results in a reversible diagnostic of model reflectivity in WRF from the hydrometeors that both matches the observed reflectivity and is consistent with the model microphysics scheme (Thompson) used in the RAP and HRRR. This work will lead to an improved analysis of radar reflectivity, including echo tops, and these initial conditions should translate into improved reflectivity and echo top forecasts from the RAP and HRRR. This improved retrieval and reflectivity diagnostic is being tested with WRFv3.4.1 and the updated Thompson microphysics scheme.

Planned:
The updated GSI version and use of GFS ensemble output in the RAP data assimilation will be executed in a May/June 2012 retrospective run including the WRFv3.4.1 model updates and associated physics changes from Tanya Smirnova and Joe Olson for the land-surface and boundary layer schemes. This RAP retrospective run with all the integrated changes will be followed by HRRR retrospective runs using this RAP retrospective run as input and the same WRFv3.4.1 model version. Evaluation of this retrospective run will include verification of radar reflectivity and echo top forecasts.

Problems/Issues/Schedule Changes Encountered or Anticipated:
None.

Task 4 – Assess HRRR reliability and provide monthly reporting

***Current*:**
Work continues towards an independent 2-computer solution for HRRR model forecast production and distribution for use in CoSPA. The RAP and HRRR are running regularly on both high-performance computer systems (Jet and Zeus) and work is ongoing to remove data flow dependencies between the two systems including

independent delivery of observational input data directly to Jet and Zeus from NCEP. The reliability of the Jet and Zeus HRRR runs are as follows:

HRRR Reliability for 0-8 Hour VIL/Echo Tops for January 2013

Jet
All runs: 82.5%
3 or more consecutive missed runs: 87.8% (most meaningful for CoSPA)
6 or more consecutive missed runs: 91.9%
12 outages of at least 3 hrs or longer
6 outages of at least 6 hrs or longer

Zeus
All runs: 76.2%
3 or more consecutive missed runs: 90.6% (most meaningful for CoSPA)
6 or more consecutive missed runs: 94.6%
14 outages of at least 3 hrs or longer
5 outages of at least 6 hrs or longer

Combined (Jet or Zeus)
All runs: 94.4%
3 or more consecutive missed runs: 97.4% (most meaningful for CoSPA)

Planned:
Work will be focused on distribution of HRRR model forecast data to ESRL/GSD from Zeus without using Jet resources through installation of a new hardware system. Networking changes will be made to permit use of a high bandwidth connection between Zeus and ESRL/GSD. Requests for dedicated computer reservations on Zeus to further increase the reliability of the HRRR will also be submitted.

Problems/Issues/Schedule Changes Encountered or Anticipated:
Significant software updates and changes on the Jet computer system including the underlying operating system and job scheduler in January has resulted in some prolonged interruptions thereby reducing the HRRR reliability on Jet during this period.

Task 4 – Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014

Tracy Smith ported SatCast assimilation code (previously developed for use with the RUC analysis) from the RUC to the RAP (GSI package). The code ingests SatCast IR cloud-top cooling data and maps it into a local heating function that is applied to the RAP fields in a similar manner to the way the RAP assimilates radar reflectivity data. Using a sample IR cloud-top cooling rate data set from a convectively active period in early July 2012, she completed a preliminary 1-day retrospective experiment (control run without the SatCast data and experiment with the SatCast data). Preliminary results indicate that for a scattered thunderstorm situation over the Southeastern U.S., assimilation of the SatCast IR cooling rates leads to a better short-term prediction of small-scale convective systems. Further work is ongoing.

Interact with CoSPA (or other) program partner labs and the FAA

Current:
Steve Weygandt and Curtis Alexander gave oral presentations and Patrick Hofmann presented a poster on RAP and HRRR model development and evaluation activities at the American Meteorological Society 16th Conference on Aviation, Range, and Aerospace Meteorology (ARAM) in January.

Planned:
A CoSPA team meeting including representatives from ESRL/GSD, NCAR/RAL, MIT/LL and the FAA was scheduled for Wednesday 13 February 2013 to discuss RAP/HRRR model development updates and related plans for the CoSPA 2013 season.

Deliverables	Delivery Schedule

Task 4 – Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA	
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use	Mar 2013
Conduct baseline testing of the early 2013 HRRR version	Mar 2013
Report on evaluation of new microphysics scheme and associated echo-top and reflectivity diagnostics in ESRL/GSD RAP and HRRR	Mar 2013
Assess HRRR reliability and provide monthly reporting	Apr 2013
Report on evaluation of revised WRFv3.4 microphysics for RAP/HRRR for its effects on echo-top and reflectivity in ESRL RAP/HRRR	Mar 2014
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2014 real-time use of HRRR	Mar 2014
Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014	Mar 2014
Report on 2014 baseline testing of the HRRR	Mar 2014

Status of MDE Deliverables – 14 FEB 2013

Legend: ☐ Deliverable on schedule; ☑ Deliverable submitted; ☐ Deliverable overdue

Deliverables	Delivery Schedule	Status	Comment
Task 1 – Improve turbulence guidance from NWP forecasts			
Finalize code for RAPv2 for implementation at NCEP	Mar 2013	☐	
Complete the testing of the 40/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data	Mar 2013	☐	
Report on early version of RAPv3 primary cycle at GSD with physics enhancements for initialization of the HRRR.	Dec 2013	☐	
Report on the optimal configurations for including satellite data in the 40/13 km dual-resolution hybrid system to ensure overall positive impacts of the data	Dec 2013	☐	
Finalize RAP version to initialize experimental HRRR for 2014 real-time use toward operational HRRR	Mar 2014	☐	
Deliver progress report on development of NARRE	Mar 2014	☐	
Deliver progress report on ensemble/hybrid data assimilation for use in NARRE	Mar 2014	☐	
Task 2 – Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE			
Report on initial tests of 3-km 15-min RTMA cloud / surface analysis for use in frontal diagnostics, CI assessment and other near-surface assessments	Feb 2013	☐	
Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for 2013 real-time use	Mar 2013	☐	
Provide preliminary 15-min RTMA surface analyses as experimental improved basis for frontal diagnostics and other diagnostics from surface analyses	Apr 2013	☐	
Report on computing resource status on NCEP Central Computing System, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR	Jun 2013	☐	
Complete FY13 internal assessment with revised 3-km HRRR running every hour	Sept 2013	☐	

Deliverables	Delivery Schedule	Status	Comment
Provide revised 15-min RTMA surface analyses as primary basis for frontal diagnostics and other diagnostics from surface analyses for real-time use in 2014	Feb 2014		
Finalize all changes to the HRRR for real-time use in 2014	Mar 2014		
Task 3 – Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE			
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Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014	Mar 2014		
Report on 2014 baseline testing of the HRRR	Mar 2014		